

Age-Matched Comparison of Elite and Non-elite Military Performers during Free Living and Intense Operational Stress

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ABSTRACT

BACKGROUND: A useful approach to quantifying factors which influence human performance involves the classification and comparison of so-called “elite” and “non-elite” performers. **OBJECTIVE:** In this pilot study, we classified 6 graduates of the Basic Underwater Demolition/SEAL training program as elite and compared them to 6 age-matched non-elite military personnel on key aspects of physiological and psychological function during free living and in response to intense military stress. **METHODS:** Participants completed measures of perceived stress and anger during daily living. Diurnal variation in heart rate (a marker of parasympathetic cardiac control) was measured via ambulatory holter monitoring. Participants were then followed during stressful survival training, where salivary cortisol was sampled during mock-captivity and acute stress responses were examined via self-report. **RESULTS:** Elite performers reported less perceived stress ($p = .07$) during daily living. Group differences in diurnal cardiac function were also observed, whereas elite performers demonstrated more substantial nocturnal heart rate dipping (29% versus 21%; $p = .08$). Although elite performers produced nearly identical cortisol responses to an overt high-stress encounter during mock-captivity, they generated much *lower* cortisol responses in the *absence* of overt challenge ($p = .003$) – a phenomenon we termed “selectivity.” Finally, elite performers reported fewer subjective stress responses to mock-captivity ($p = .08$) than their non-elite counterparts. **CONCLUSIONS:** Elite and non-elite military performers differ across several criteria both during free living and in response to intense stress. Of particular importance, elite performers demonstrate greater “selectivity” in response to overt stressors – a possible marker of adaptability or resilience. Results are discussed within the evolutionary paradigm of “predator imminence.” These findings have broad implications for the identification, selection, and training of elite performers in high-stress occupations.

INTRODUCTION

Over the years, there has been a sustained interest in identification and selection of individuals who are best adapted to perform in high risk, high-stress operational contexts (Damos et al., 2007; Weeks, 2000; Doherty et al., 2006; Hertzka, 1956). Military aviation, for instance, has an extensive history of systematically identifying and selecting individuals thought to possess characteristics most conducive to success in pilot training (Damos et al., 2007; Weeks et al, 2000). Also, the rigorous (albeit experimental) process of selecting the first Project Mercury astronauts is depicted in the famous book by Tom Wolfe entitled “The Right Stuff” (1979). Military special operations communities have historically faced extremely high (and mostly voluntary) attrition rates (Doherty et al., 2006) which has prompted multiple efforts to identify individuals most likely to endure such arduous training (Gunderson et al., 1972; Horgen et al., 2007). In light of today’s Global War on Terror, there remains a great interest in identifying, selecting, and retaining individuals who are best equipped to succeed in complex, asymmetric and stressful military operations.

A useful approach to help elucidate characteristics underlying successful human performance in high-stakes environments is to classify individuals according to an established performance criterion and then examine between-group differences. Such approaches are not without precedent. For instance, in the sport science literature, Thomas et al. (1999) divided a sample of athletes into those who performed at the international level and those who did not; they found that international-level athletes used a wider range of “psychological strategies” than did collegiate, regional, and recreational athletes. More recently, we investigated differences in the performance strategies of U.S. Olympic medalists and nonmedalists from the 2000 Sydney

Olympic Games during both practice and competition (Taylor *et al.*, 2008). With respect to sport competition, while the medalists indicated greater emotional control and automaticity (i.e., performing skills in automatic-like fashion) than non-medalists, greater use of mental imagery (i.e., mental rehearsal) prevailed for non-medalists. From this we concluded that the less successful athletes may have used more mental imagery to rehearse their sport skills because they were not executing at the same level of automaticity as that observed in the more successful Olympians. During practice, medalists reported greater emotional control and use of positive self talk (i.e., internal dialogue) than non-medalists.

This research strategy has been used extensively in military research to compare individuals who complete arduous training programs (e.g., Special Forces or Special Operations) to those who do not (McDonald *et al.*, 1990, Taylor *et al.*, 2007). In our recent work (Taylor *et al.*, 2007), eight Basic Underwater Demolition/ SEAL (BUD/S) instructors serving as subject matter experts completed questionnaires that surveyed the extent to which several individual characteristics differentiated trainees who successfully completed from those who dropped out on request from BUD/S training. Subject matter experts (SMEs) were then presented with the aggregated questionnaire data and engaged in a discussion of factors believed to influence attrition. The characteristics which were most consistently reported across both data collection formats to differentiate the groups included mental toughness, the will to win, physical strength, and physical endurance.

Morgan and colleagues have further applied this research strategy by comparing “elite” (i.e., Army Special Forces) and “non-elite” warfighters (i.e., non-Special Forces soldiers) during Survival, Evasion, Resistance, and Escape (SERE) School. SERE school exposes students to a harsh and realistic environment where they are taught to survive, evade “enemy” captors, resist

exploitation, and escape during mock-captivity. In one study (Morgan, Wang et al., 2001), no significant differences were observed between Special Forces and non-Special Forces Army soldiers in the cortisol response to survival training, although Special Forces soldiers exhibited greater responses in plasma norepinephrine. These same researchers have demonstrated greater neuropeptide Y (a peptide implicated in stress resilience and neuroprotection) responses to survival training in Special Forces warfighters compared to their non-elite counterparts (Morgan, Wang et al., 2000; Morgan Rasmusson et al., 2002).

Our program of research also addresses individual differences in stress resilience during SERE training. The purpose of the current pilot study was to explore differences between “elite” and “non-elite” military performers across a spectrum of physiological and psychological factors – both during free living and in response to intense military stress. Specifically, we classified six recent graduates of the BUD/S program (Naval Special Warfare Center, San Diego, CA) who were officers and college graduates as “elite” performers and compared them to an age-matched group of recent graduates from the 5-week Navy Aviation Rescue Swimmer School (Pensacola, FL), who were enlisted and were high school graduates. The latter group was classified as “non-elite.” Although the rescue swimmer program is mentally stressful and physically rigorous, the 6-month Navy BUD/S program is widely considered to be among the most stressful and challenging of all military training programs worldwide. Both programs heavily emphasize physical strength and endurance, aquatic skills and tactical proficiency under stressful conditions. In sum, the elite group is discerned from the non-elite group by virtue of a widely-accepted performance criterion, educational level attained and leadership involvement. Observed group differences cannot be attributed to any one of these ingredients exclusively.

It was hypothesized that the elite performers would have lower self-reported stress during daily living and would report less psychological impact of stressful survival training. We also predicted that elite performers would demonstrate similar cortisol responses to mock-captivity problems during SERE training. We further explored group differences in anger expression and cardiac control during free living, as well as physiological stress reactivity during survival training in the *absence* of an overt stressor. No directional hypotheses were advanced for these exploratory components of the study.

METHODS

Overview of Procedures

This study was approved by the Institutional Review Board at the Naval Health Research Center, San Diego, CA. Prior to participation, all prospective participants were informed of their rights as human subjects and each gave written, informed consent to participate. Approximately three weeks prior to participating in SERE training in the San Diego area, participants completed self-report measures of stress and anger expression. Also, heart rate dipping (i.e., percent change in HR from wake to sleep) was measured across a 24 hour period using ambulatory monitoring and sleep-wake was quantified via actigraphy. Participants then attended SERE training, during which salivary cortisol was measured to study physiologic stress and the psychological impact of stressful mock-captivity was measured via self-report.

Perceived Stress

The PSS-10 (Cohen *et al*.) is a 10-item questionnaire examining the role of nonspecific appraised stress that people have experienced in the last month. This scale has been used widely in a broad cross-section of the population. Examples of items include “How often have you been

upset because of something that happened unexpectedly?”, “How often have you felt nervous and ‘stressed’?” and “How often have you felt that you were on top of things?” All items are scored with a 5-point Likert scale ranging from 0 (never) to 4 (very often), with a possible total score of 40. Cronbach’s alpha reliability in the current sample was .91.

Anger Expression

Self-report anger expression was assessed through the State Trait Anger Expression Inventory -2 (STAXI-2; Spielberger, 1999). The STAXI-2 is a 57-item inventory that measures the intensity of anger as an emotional state (State Anger) and the disposition to experience angry feelings as a personality trait (Trait Anger). The instrument consists of six scales, five subscales and an Anger Expression Index. For this measure, respondents are instructed to read the statements and then indicate the extent to which each statement describes him or her. Examples of items include, “I get angry when I am slowed down by others’ mistakes” (Angry Reaction), “I am quick tempered” (Angry Temperament), “I express my anger” (Outward Anger Expression), and “I keep things in (Inward Anger Expression). All items are rated with a 4-point Likert Scale ranging from 1 (Almost Never) to 4 (Almost Always). The two anger expression scales used in the current pilot study were Outward Anger Expression (the tendency to express anger in aggressive behavior directed toward other persons or objects in the environment; Cronbach’s alpha = .54, total possible score = 32), and Inward Anger Expression (the tendency to frequently experience intense angry feelings but to suppress these feelings rather than express them physically or verbally; Cronbach’s alpha = .83, total possible score = 32). An item analysis review was conducted to determine if specific items from the Outward Anger Expression Scale could be removed to improve the reliability. Two items with poor item-total correlations were

removed, yielding a Cronbach alpha of .85 and a total possible score of 24 rather than 32. The revised version of this subscale was then used for all relevant statistical analyses.

24-Hr Actigraphy Measurement

Duration of sleep and wake periods were measured using the Octagonal Basic Motionlogger Actigraph (Precision Control Design, Inc., Fort Walton Beach, FL), coincident with ambulatory heart rate monitoring (described below). The Motionlogger Actigraph is a wrist-sized accelerometer and microprocessor that measures physical movement and is a widely used marker of sleep and wake. The HR data were separated into sleep and wake phases based on the actigraphic data.

Ambulatory Heart Rate Monitoring

Participants were monitored for 24 hours with electrocardiography (ECG). The signal was recorded using the Aria Holter monitor (Del Mar Reynolds Medical, Irvine, CA). The records were then reviewed and edited using the Impresario Holter analysis system (Del Mar Reynolds Medical). R-R intervals were used to quantify HR. As noted above, sleep and wake HR measurements were separated. Therefore we were able to observe sleep-related *decreases* in HR (calculated as percent change from waking HR: $[\text{Wake HR} - \text{Sleep HR}] \div \text{Wake HR}$). This construct, referred to as “heart rate dipping,” is a correlate of sleep-phase parasympathetic modulation (acetylcholine-mediated component responsible for calming of nervous system and return to normal function after stress exposure), and by extension, may serve as a novel marker of adaptability or resilience. A recent study links greater HR dipping with lower risk of all-cause mortality (Ben-Dov *et al.*, 2007), and elevated heart rate in general is associated with cardiovascular and noncardiovascular death (Palatini *et al.*, 2006).

Military Survival Training

SERE training and our associated program of research have been described in earlier reports (Taylor, Sausen, Mujica-Parodi et al., 2007; Taylor, Sausen, Potterat et al., 2007) and some portions of the curriculum are classified. Briefly, United States military members deemed “high risk of capture” are required to attend this course, which includes a period of mock-captivity. After an initial phase of classroom-based didactic training, students are taken to a field training site where they receive applied training in survival, evasion, resistance, and escape techniques. Training tasks include evasion from a simulated enemy and, upon eventual “capture,” students must practice resistance to various forms of simulated exploitation in stressful, mock captivity-related training challenges. Since SERE training is designed, in part, to simulate a captivity experience, it offers a unique medium in which to prospectively study the effects of highly realistic mock-captivity stress on human functioning.

Physiologic Stress

Cortisol is the end product of hypothalamic-pituitary-adrenal stimulation and is the most widely-used marker of stress. It is responsible for stimulating blood glucose for energy and increasing blood pressure in support of the stress response. Physiologic stress was evaluated via salivary cortisol sampling during the mock-captivity phase of survival training. Specifically, one data point was collected during mock-captivity in the absence of any overt challenge (i.e., direct threat) while a second data point was collected directly after a stressful mock-captivity challenge. The saliva samples were collected in Salivette tubes (Sarstedt, Inc., Newton, NC), which were individually labeled with the date and time of sampling. Salivary cortisol was measured using a Coat-A-Count radioimmunoassay kit (Diagnostic Products Corporation, Los Angeles, CA). It

was measured with sensitivity (detectability) of 0.7-55.2 nmol/L and intra- and inter-assay coefficients of variation of 3-7% and 5%, respectively.

Self-Reported Stress

The Impact of Events Scale-Revised (IESR; Weiss & Marmar, 1997) is a self-report measure designed to assess current subjective distress for any specific life event. It has three subscales comprising 22 items: avoidance (IESR-Avoid; mean of 8 items measuring the extent to which the respondent avoids situations that remind him or her of the stressful or traumatic event), intrusion (IESR-Intrusion; mean of 8 items assessing the extent to which one experiences intrusive thoughts), and hyperarousal (IESR-Arousal; mean of 6 items measuring anger, irritability, heightened startle response, and hyperarousal). The total impact of events score (IESR-Total) is the mean of all 22 items. In the current study, respondents completed the IESR 24 hours after the conclusion of survival training. The directions were modified to ask the participant to indicate how distressing each difficulty has been with respect to the high-intensity stressor encountered during mock-captivity on a scale of 0 (*not at all*) to 4 (*extremely*). Adequate reliability and predictive validity have been shown for this scale (Weiss & Marmar, 1997), and Cronbach's alpha reliabilities in the present sample were .78, .83, and .78 for IESR-Arousal, IESR-Avoid, and IESR-Intrusion, respectively. Cronbach's alpha reliability for IESR-Total was .92, and the mean IESR-Total score was .94 ($SD = .61$).

Data Analysis

Preliminary descriptive statistics were performed to check for normality of distributions for all independent and dependent variables and to screen for the presence of influential outlying data values. These plots revealed that the normal distribution was an appropriate assumption for all variables. Means (and standard deviations) and percentages were used to describe continuous

and discrete characteristics, respectively. General linear model (GLM) univariate analyses were performed to assess differences between the elite and non-elite study participants relative to the physiological and psychological endpoints of interest. Partial eta squared values (η^2) were calculated to estimate effect sizes. SPSS Statistical Software System, version 16 (SPSS Inc., Chicago, IL) was used to perform all analyses. All hypothesis tests were two-sided and, given the small sample size and exploratory nature of selected study components, the Type I error rate was set at .1 rather than the conventional .05.

RESULTS

Characteristics of the Sample

Detailed characteristics for the entire sample and for each subgroup are presented in Table 1. Mean age, body mass index (BMI), and years of military service for the total sample were 23.3 years (SD = 0.8), 25.8 kg/m² (SD = 0.9), and 1.7 years (SD = 1.3), respectively. Most participants (n = 10, 83.3%) were Caucasian, while one participant (8.3%) was Hispanic and one (8.3%) was of mixed ethnicity. Elite and non-elite participants were matched with respect to age and therefore did not differ on this variable. No group differences prevailed for BMI or years of military service. Of note, the elite participants were all college graduates and officers, while the non-elite participants were high school graduates and enlisted. These additional differences were incidental, occurring as a product of convenience sampling.

Elite Non-elite Comparison: Psychological and Physiological Characteristics during Daily Living

Characteristics for the total sample and each subgroup during daily living are displayed in Table 1. Elite participants reported less perceived stress ($p = .07$, $\eta^2 = .30$) than non-elite participants. No group differences prevailed relative to anger expression. Elite participants demonstrated greater heart rate dipping than their non-elite counterparts (29% versus 21 %, $p = .08$, $\eta^2 = .28$).

Elite Non-elite Comparison: Psychological and Physiological Responses to Intense Military Stress

Responses to military stress are displayed in Table 1. Although elite performers produced nearly identical cortisol responses to an overt high-stress encounter during mock-captivity, they generated much *lower* cortisol responses in the *absence* of overt challenge ($p = .003$, $\eta^2 = .61$). Finally, elite performers self-reported less subjective stress responses to mock-captivity ($p = .08$, $\eta^2 = .27$). We further explored group differences relative to the IESR subscales and observed lower values in the elite group relative to IESR-Avoidance ($p = .07$, $\eta^2 = .30$) but not IESR-Intrusion or IESR-Arousal.

DISCUSSION

This pilot study was initiated to explore differences between “elite” and age-matched “non-elite” military performers across several physiological and psychological factors – both during free living and in response to intense military stress. Our findings suggest that these groups differ across multiple criteria. Elite participants reported less perceived stress during daily living than their non-elite counterparts, and also demonstrated more substantial heart rate dipping during free living as well as more “selective” responses to overt military stress. Taken together,

these data may reflect key group differences in resilience and may have broad implications for the identification, selection, and training of individuals in high-performance, high-stress occupations.

Elite participants demonstrated more substantial heart rate dipping during daily living than non-elite participants. This phenomenon is a correlate of sleep-phase parasympathetic modulation. The parasympathetic nervous system is responsible for calming of the nervous system and restoration of homeostasis. Parasympathetic activity generally increases during sleep, and greater heart rate dipping (amount of change from wake to sleep) may reflect more restorative sleep. A recent study links greater HR dipping with lower risk of all-cause mortality (Ben-Dov *et al.*, 2007), and elevated heart rate in general is associated with cardiovascular and noncardiovascular death (Palatini *et al.*, 2006). Further, it has been proposed that individuals with greater cardiac vagal modulation may show more endurance under stressful situations inasmuch as they may be more capable of self-regulation under stress (Porges 2007). In their pioneering stress research in the military domain, Morgan *et al.* (2007) examined heart rate variability (HRV) as a predictor of performance during extreme military training. These scientists measured vagal tone in healthy participants enrolled in Navy SERE training and Combat Diver Qualification Course, respectively. They consistently observed a significant relationship between low vagal tone and superior performance. Although this finding is somewhat counterintuitive, it is noted that the HRV analyses were performed during classroom phases of training, just prior to the stressful field exercises. These observations, then, may not reflect a true “baseline,” but rather may demonstrate an adaptive vagal suppression in anticipation of the stressful field exercises (i.e., the “pregame mindset” [Morgan, personal communication]). We are currently engaging in collaborative work with these scientists using

24-hour ambulatory heart rate monitoring 2-3 weeks prior to SERE training in order to control for possible anticipatory stress responses. Clearly, this is an exciting area of research and more work is needed to better understand connections between cardiac modulation, stress, and human performance in extreme environments.

Elite participants also demonstrated more “selective” stress responses than non-elite participants. We define selectivity as “the innate or learned ability to generate an adaptive stress response in the presence of overt threat while effectively suppressing stress responses in the absence of overt threat.” Explicitly, although elite performers produced nearly identical cortisol responses to an overt high-stress encounter during mock-captivity, they generated much *lower* cortisol responses in the *absence* of overt challenge. This crucial finding may be interpreted within the evolutionary principle of “predator imminence.” This principle suggests that an organism’s survival is predicated upon its ability to switch flexibly between defensive states in response to threat (Mobbs *et al.*, 2007). A key component of this defensive switching involves a continuum whereby distinct threat states are configured according to whether a predator is distal or proximal to the prey. The “pre-encounter” stage is characterized by no immediate danger; “post-encounter,” is where threat is detected; and “circa-strike,” is defined as a direct interface with the threat stimulus. Research suggests that distinct neurobiological patterns are reflected along this continuum. Distal threat is purported to elicit activity in prefrontal cortical areas (possibly reflecting complex planning and avoidance strategies), while proximal threat elicits activity in embryologically older parts of the brain (e.g., limbic system, midbrain) which control reflexive behaviors (e.g., fight-or-flight) (McNaughton *et al.*, 2004). Interpreting our results within this theoretical context, it appears that elite performers may more selectively (i.e.,

efficiently) configure their flight-or-fight responses according to the predator imminence continuum.

These data also extend previous work in the survival training context. Morgan, Wang et al., (2001), for instance, also found no significant differences between elite Special Forces and non-Special Forces Army soldiers in the cortisol response to mock-captivity challenges, although Special Forces soldiers did exhibit greater responses in plasma norepinephrine. These researchers have also demonstrated greater neuropeptide Y (implicated in stress resilience and neuroprotection) responses to survival training in Special Forces warfighters compared to their non-elite counterparts (Morgan, Wang et al., 2000). Twenty-four hours after the removal of stress, Special Forces soldiers' NPY levels had returned to baseline while non-Special Forces soldiers exhibited levels that were *below* baseline, suggesting depletion due to stress exposure. Synthesizing these findings, it appears that elite and non-elite performers may have distinguishable, analyte-dependent profiles in response to intense stress. It is possible that elite performers conserve energy by effectively suppressing the stress response in the absence of overt threat and may also produce more stress-buffering metabolites during overt threat. Thus, it seems valuable to study individual differences not only in recovery from stress but also in the absence of overt threat.

Several limitations of this study should be addressed. First, our classification of performers into "elite" and "non-elite" categories was performed solely to differentiate groups based on a widely accepted performance criterion in hopes of gaining insight into factors influencing human performance. In no way does this imply that members of the non-elite group are not highly capable or high-performing. By contrast, the rescue swimmer program is regarded as one of the most rigorous in the Navy community and its graduates are well-prepared for

important life-saving roles. If we had instead compared a low-performing group to the elite performers, it is expected that the observed differences would have been of a much greater magnitude. We also recognize that the groups differed with respect to education and officer/enlisted status. Finally, it can not be inferred from our current study whether the adaptive stress reactions observed in the elite performers are inherent (i.e., genetically predisposed), developed during their arduous training program, or some interaction of the two.

Future research comparing so-called elite and non-elite performance groups may benefit from controlling for additional demographic variables, such as education and officer/enlisted status. It would also be interesting to *prospectively* evaluate the earlier-described notion of “selectivity” in elite performers to determine whether it is a preexisting characteristic or one that is developed during professional training. Also, heart rate dipping data are easily and non-invasively collected, and appears to hold great promise as a marker of general health and physiologic resilience during daily living. It may also be useful in further studies examining individual, operational, and occupational stress as well as a marker of cardiovascular and all-cause morbidity and mortality. Validation of this method against more commonly used measures of heart rate variability would also be valuable.

In summary, we examined differences between “elite” and “non-elite” military performers both during free living and in response to intense military stress. Elite participants reported better psychological health in comparison to their non-elite counterparts, and also demonstrated greater physiologic resilience during both free living and intense military training. It is expected that these preliminary findings will stimulate future research and strengthen current efforts to identify, select, and train individuals in high-performance, high-stress occupations.

Disclaimer Information

Disclaimer: The study protocol was approved by the Naval Health Research Center Institutional Review Board in compliance with all applicable Federal regulations governing the protection of human subjects.

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References

1. Damos, DL. Foundations of military pilot selection systems: World War I. Technical Report 1210. Arlington, VA, U.S. Army Research Institute for Behavioral and Social Sciences, 2007.
2. Weeks, JL United States Air Force Pilot Selection. AFRL-HE-AZ-TP-2000-0004, Mesa, AZ, Air Force Research Laboratory, 2000.
3. Doherty LM, Trent T, Bretton GE. Counterattrition in Basic Underwater Demolition/SEAL Program: Selection and Training. Special Report 81-13. San Diego, CA, Navy Personnel Research and Development Center, 1981.
4. Hertzka AF, Anderson AV. Selection requirements for Underwater Demolition Team training. Bureau of Naval Personnel Tech. Bul. No. 57-6. San Diego, CA, United States Naval Personnel Research Field Activity, 1956.
5. Wolfe, T. *The Right Stuff*. New York: Picador, 1979.
6. Horgen, K., Dorio, J.M., Krain, B., Judge, C.L., Mottern, J., Rice, C.P., Melton, J., Potterat, E.G., Taylor, M.K., Whanger, J., Bourne, M., Wyne, J., Noble, J. (2007). Concurrent validation of a psychological test battery for Navy Basic Underwater Demolition / SEAL candidates. *Personnel Decisions Research Institutes Technical Report No. 576*.
7. Thomas, P.R., Murphy, S.M. and Hardy, L. (1999). Test of Performance Strategies: development and preliminary validation of a comprehensive measure of athletes' psychological skills. *Journal of Sports Sciences*, 17(9), 697-711.
8. Gunderson EKE, Rahe RH, Arthur RJ: Prediction of performance in stressful Underwater Demolition Training. *J Appl Psychol* 1972; 56(5): 430-2.

9. Taylor, M.K., Larson, G.E., Miller, A., Mills, L., Potterat, E.G., Reis, J.P., Padilla, G.A., Hoffman, R.J. (2007). Predictors of Success in Basic Underwater Demolition/SEAL (BUD/S) Training—Part II: A Mixed Quantitative and Qualitative Study. *Naval Health Research Center Report No. 07-10*.
10. Taylor, M.K., Gould, D., Rolo, C. (2008). Performance strategies of U.S. Olympians in practice and competition. *High Ability Studies*, 19(1), 15-32.
11. Morgan CA, III, Rasmusson AM, Wang S, et al. Neuropeptide-Y, cortisol, and subjective distress in humans exposed to acute stress: replication and extension of previous report. *Biol Psychiatry* 2002 Jul 15;52(2):136-42.
12. Morgan CA, III, Wang S, Mason J, et al. Hormone profiles in humans experiencing military survival training. *Biol Psychiatry* 2000 May 15; 47(10):891-901.
13. Morgan CA, III, Wang S, Rasmusson A, et al. Relationship among plasma cortisol, catecholamines, neuropeptide Y, and human performance during exposure to uncontrollable stress. *Psychosom Med* 2001 May-Jun; 63(3):412-22.
14. Cohen, S., & Williamson, G. Perceived stress in a probability sample of the United States. In S. Spacapam & S. Oskamp (Eds.), *The social psychology of health: Claremont Symposium on applied social psychology* (pp. 31-67). Newbury Park, CA: Sage; 1988.
15. Weiss DS, Marmar CR: The Impact of Event Scale-Revised. In: Wilson J, Keane T, eds. *Assessing Psychological Trauma and PTSD*, pp 399-411. New York, Guildford, 1997.
16. Ben-Dov, IZ, Kark, JD, Ben-Ishay, D, Mekler, J, Ben-Arie, L, Bursztyn, M. Blunted heart rate dip during sleep and all-cause mortality. *Arch Intern Med* 2007; 167(19): 2116-2121.
17. Palatini, P. Heart rate: a cardiovascular risk factor that can no longer be ignored. *G Ital Cardiol*. 2006; 7(2): 119-128.

18. Porges, SW. 2007. The polyvagal perspective. *Biol Psychol* 74:116–143.
19. Mobbs, D., Petrovic, P., Marchant, JL, Hassabis, D., Weiskopf, N, Seymour, B, Dolan, RJ, Frith, CD. When fear is near: threat imminence elicits prefrontal-periaqueductal gray shifts in humans. *Science*, 317, 1079-1083.
20. McNaughton, N, Corr, PJ. A two-dimensional neuropsychology of defense: fear/anxiety and defensive distance. *Neurosci Biobehav Rev*, 28(3), 285-305.
21. Taylor MK, Sausen KP, Mujica-Parodi LR, et al: Neurophysiologic methods to measure stress during Survival, Evasion, Resistance, and Escape training, *Aviat Space Environ Med* 2007; 78: B224-B230.
22. Taylor, M.K., Sausen, K.P., Potterat, E.G., Mujica-Parodi, L.R., Reis, J.P., Markham, A.E., Padilla, G.A., Taylor, D.L. Stressful Military Training: Endocrine Reactivity, Performance and Psychological Impact. *Aviat Space Environ Med* 2007; 78(12), 1143-1149.
23. Gunderson EKE, Rahe RH, Arthur RJ: Prediction of performance in stressful underwater demolition training. *J Appl Psychol* 1972; 56(5): 430-2.
24. McDonald DG, Norton JP, Hodgdon JA: Training success in U.S. Navy Special Forces. *Aviat Space Environ Med* 1990; 61: 548-54.

Table 1. Characteristics of elite and non-elite military performers

Variable	N	Total Sample		N	Elite Performers		Non-Elite Performers	
		Mean (SD)	Range		Mean (SD)	N	Mean (SD)	
Age (Years)	12	23.3 (0.8)	23.0 – 25.0	6	23.3 (0.8)	6	23.3 (0.8)	
Body Mass Index (kg/m ²)	12	25.8 (0.9)	24.5 – 27.2	6	25.5 (0.7)	6	26.0 (1.0)	
Years of Military Service (Years)	12	1.7 (1.3)	1.0 – 5.0	6	2.1 (1.7)	6	1.3 (0.4)	
Perceived Stress	12	19.3 (5.8)	12.0 – 29.0	6	16.3 (4.1)	6	22.3 (5.9)*	
Anger Expression-In	12	15.8 (4.7)	9.0 – 24.0	6	15.7 (4.2)	6	15.8 (5.6)	
Anger Expression-Out	12	10.2 (3.1)	6.0 – 18.0	6	10.0 (2.1)	6	10.3 (4.1)	
Heart Rate Dipping (% change wake-sleep)	12	25.7 (7.8)	13.0 – 37.0	6	29.8 (7.1)	6	21.8 (6.8)*	
Cortisol-Overt Challenge (nmol/L)	12	24.9 (12.5)	8.8 – 50.2	6	25.2 (13.6)	6	24.6 (12.6)	
Cortisol-No overt challenge (nmol/L)	12	13.2 (7.3)	4.1 – 24.5	6	7.8 (3.7)	6	18.7 (5.6)***	
Impact of Events-Total	12	1.0 (0.8)	0.0 – 2.3	6	0.7 (0.6)	6	1.4 (0.8)*	
Impact of Events-Avoidance	12	0.9 (0.8)	0.0 – 2.1	6	0.5 (0.7)	6	1.3 (0.8)*	
Impact of Events-Arousal	12	1.0 (0.8)	0.0 – 2.5	6	0.6 (0.7)	6	1.4 (0.8)	
Impact of Events - Intrusion	12	1.2 (0.8)	0.0 – 2.4	6	0.8 (0.6)	6	1.5 (0.9)	

* Significantly different from elite performers (p < .1)

*** Significantly different from elite performers (p < .01)

REPORT DOCUMENTATION PAGE

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14. ABSTRACT (maximum 200 words) BACKGROUND: A useful approach to quantifying factors which influence human performance involves the classification and comparison of so-called “elite” and “non-elite” performers. OBJECTIVE: In this pilot study, we classified 6 graduates of the Basic Underwater Demolition/SEAL training program as elite and compared them to 6 age-matched non-elite military personnel on key aspects of physiological and psychological function during free living and in response to intense military stress. METHODS: Participants completed measures of perceived stress and anger during daily living. Diurnal variation in heart rate (a marker of parasympathetic cardiac control) was measured via ambulatory holter monitoring. Participants were then followed during stressful survival training, where salivary cortisol was sampled during mock-captivity and acute stress responses were examined via self-report. RESULTS: Elite performers reported less perceived stress ($p = .07$) during daily living. Group differences in diurnal cardiac function were also observed, whereas elite performers demonstrated more substantial nocturnal heart rate dipping (29% versus 21%; $p = .08$). Although elite performers produced nearly identical cortisol responses to an overt high-stress encounter during mock-captivity, they generated much <i>lower</i> cortisol responses in the <i>absence</i> of overt challenge ($p = .003$) – a phenomenon we termed “selectivity.” Finally, elite performers reported fewer subjective stress responses to mock-captivity ($p = .08$) than their non-elite counterparts. CONCLUSIONS: Elite and non-elite military performers differ across several criteria both during free living and in response to intense stress. Of particular importance, elite performers demonstrate greater “selectivity” in response to overt stressors – a possible marker of adaptability or resilience. Results are discussed within the evolutionary paradigm of “predator imminent.” These findings have broad implications for the identification, selection, and training of elite performers in high-stress occupations.					
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